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STRATIGRAPHY OF THE SKYKOMISH BASIN, WASHINGTON

WARREN S. SMITH
Berlin, Washington

WITH

REPORT UPON PALEONTOLOGY AND PALEOPHYTOLOGY

CAROLINE A. DUROR

STRATIGRAPHY

I. GENERAL AREAL DISTRIBUTION

In general, the rocks of the Skykomish Basin trend in a north-south direction. This is almost exactly true of the igneous and metamorphic terranes. Only the sedimentary Swauk and the tufaceous Keechelus series vary from this general statement, for they show a trend in general west of north but bending northward on their northern prolongation. Dawson has remarked this tendency of all the rocks of the Cordilleran system.[1] The rocks lie in roughly parallel bands in the north, but are replaced southward until the granodiorite entirely takes the place of the earlier series and extends over nearly the entire width of the quadrangle. Igneous rocks greatly predominate in the area, metamorphics and sedimentaries being approximately equal in amount, and both being comparatively small. Volcanics make up a smaller division. These relations will be illustrated by the following classification table:

Snoqualmie granodiorite	130.90
Keechelus andesitic series	32.20
Tye soda granite and Beckler stock	24.15
Easton schist	22.95
Swauk sedimentary series	56.00
Maloney metamorphic series	14.80
Index granodiorite	4.35
Surface outcrop areas	285.35 sq. mi.

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[1] G. M. Dawson, "Geological Record of the Rocky Mountain Region in Canada," *Bu Geol. Soc. Am.*, XII (1901), 59.

In the following discussions no effort will be made to subdivide the metamorphic rocks of a sedimentary origin from those of an igneous origin, where these are so intimately associated as to make the subdivision impracticable. However, the schists of the northeastern area are easily kept distinct from the metamorphic series of the northwestern area.

On stratigraphical grounds the rocks readily fall into two groups: (1) the pre-Tertiary, and (2) the Tertiary. The division line between these is the most marked unconformity in the Cascades. We have present a schist, belonging to the pre-Tertiary, which is cut by quartz and igneous rock dikes, making the oldest or basal terrane.

This is called the Easton schist, and it forms the metamorphic terrane in the northeast. No definite idea of its age can be suggested except that it is pre-Ordovician. Fragments of it are included in the Mesozoic batholiths, and it is more complexly folded than the Maloney (Gunn Peak) metamorphic series. The next younger series belongs on paleontologic and correlation evidence to the Ordovician. It is a series of quartzites, schists, and crystalline limestones with associated greenstones, approximately 4,000 feet thick, outcropping in the northwest. Weaver correlates this series with the Cache Creek series as defined by Dawson.[1] It has at least one stage less of dynamic history than the Easton and on lithologic grounds it is believed to be equivalent to Smith's Peshastin series of the Snoqualmie area; but its fossil content identifies it as Ordovician instead of Carboniferous, as the Peshastin is called by Smith and the Gunn Peak by Weaver. Nothing can be said of the remainder of the Paleozoic history of the area. The absence of later Paleozoic and Triassic seems to be general in the region of the Cascade Mountains. In Jurassic time, however, there was a notable period of deep-seated volcanic activity, resulting in the intrusion of the great Sierra Nevada-Cascade granodiorite batholith, possibly the greatest of igneous intrusions.[2] This batholith is represented by two terranes in the Skykomish Basin. The first is the Tye soda granite in the northeast, and the second is the Index granodiorite in the northwest. The Cretaceous is not represented but is known to occur as a marine series farther northward. Following the Mesozoic batholithic intrusion came a positive orogenic movement, corresponding to the Laramie revolution, which left the Cascade area, at the close of the Mesozoic, high above sea-level.

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[1] G. M. Dawson, *Ann. Rept. Can. Geol. Surv.*, N.S., VII (1894), 37B–49B.

[2] R. A. Daly, *Igneous Rocks and Their Origin* (1914), p. 53.

The Tertiary period opened with a period of continental deposition in which the Swauk sandstone was deposited unconformably on the eroded edges of earlier metamorphic rocks. These arkoses consist of mingled fragments of granitic rock and of schist derived from the Paleozoic metamorphic series and from the Mesozoic batholith. Both Smith and Willis consider these arkoses to be lake deposits, but Weaver more correctly designates them as purely continental. They show conglomeratic facies and cross-bedding and vary so markedly in thickness that only the maximum figure of 4,000 feet is of any significance. They are equivalent to the lower Puget of western Washington and, on paleophytological grounds, to the Fort Union of the Montana-Wyoming areas. No definite information is recorded of the late Eocene and Oligocene, the gap being succeeded by Miocene andesitic tuff beds. These are volcanic tuff ejectamenta cut by dike- and sheet-like intrusions of andesitic composition. We have insufficient evidence to suggest where these tuffs had their immediate source, but their chemical resemblance to the Miocene granodiorite suggests forcibly that they were derived from the same magma. In later Miocene a recurrence of deep-seated vulcanism took place, resulting in the injection of the Snoqualmie granodiorite, which is the most important terrane present in the area. This batholith, if its texture is to be accounted for, must have been covered by at least 2,000 feet of rock. In this cover late Eocene and Oligocene may be included. In latest Miocene and in early Pliocene the region was planed to a low relief; a disturbance of isostatic equilibrium followed, which resulted in the arching up of the Cascade Mountains to a maximum height of approximately 8,000 feet. Since this Pliocene uplift, canyons some 5,000 feet deep have been cut in the granodiorite, a fact bearing witness to the severity of erosion experienced by the area.

In the Pleistocene the Skykomish Basin was eroded by valley glaciers, and the only discernible post-Tertiary volcanic history is recorded in a thin layer of ash, probably drifted from Mt. Rainier by prevailing southwest winds. Post-Pleistocene time has not lasted long enough seriously to change the aspect of the topography left by glaciation.

II. PRE-TERTIARY HISTORY

PRE-MESOZOIC

The pre-Mesozoic is represented by two divisions, one of which is considerably older than the other, and on lithologic grounds is referred to an equivalency with the Easton schist. The later division has experienced at least one stage less of metamorphic history and is of known Ordovician age, on the evidence of fossils obtained from a cherty phase of the limestone lens outcropping in Lowe Gulch (D 2), two miles west of Grotto. No evidence of the exact age of the Easton schist has been put forth and none can be suggested for the Skykomish Basin. It comprises extremely metamorphosed and crumpled rocks generally derived from sediments. This structural condition of the rocks precludes any estimate as to their original thickness, but does enable one to infer that they are of considerably greater age than any other Paleozoic division which is much less dynamically disturbed.

MALONEY

The Maloney comprises a series of metamorphosed rocks including quartzites, limestones, and schists of sedimentary origin cut by basic igneous rocks, usually best described as greenstones, which are later in age than the Maloney, but which on the evidence of their extreme metamorphism are considered to be also of Paleozoic age. The name Maloney is applied to a series formerly believed to be equivalent to the Peshastin series, which is called Carboniferous in age. The evidence on which this correlation is made is presented in an earlier paper.[1] Subsequent identification of fossils found in the limestone lenses shows the formation to be Ordovician in age, and therefore the name Maloney is suggested.

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[1] Warren S. Smith, "Petrology and Economic Geology of the Skykomish Basin, Washington," *School of Mines Quarterly*, XXXVI (1915), 157.

Miss Caroline A. Duror, in another part of this paper, has identified the following fossils as of Ordovician age: *Rafinesquina deltoidea* and *Illaenus americanus*. This is the first recorded evidence of the presence of Ordovician strata in the Cascade Mountains of Washington, and both fossils are the first of their kind of Paleozoic age to be found there. With this Ordovician series begins the definitely known geologic history of the Skykomish Basin. It was a period during which the area stood approximately at sea-level, as evidenced by the fact that the limestone lenses carry marine fossils. The presence of quartzite shows that probably the area was not deeply submerged, but more probably was near the continental margin. There is no record of the post-Ordovician Paleozoic.

MESOZOIC

There are no Mesozoic deposits at present, though there is evidence that they must have existed. The sole known event of the Mesozoic in the Skykomish Basin is the intrusion of batholithic igneous rocks whose structural relations identify them as Mesozoic, though there is no other positive evidence of their age. But it is altogether probable that the batholiths were intruded as a part of the great Sierra Nevada intrusion identified in California and Oregon as of Jurassic age. Daly, Smith and Calkins, Russell, Weaver, and others assert this probability. The granodiorite of which this batholith is composed is granitoid in texture, and such a texture can be established only under a thick cover of superjacent rock. This cover was removed in post-Jurassic time, leaving the batholith uncovered at the end of the Mesozoic. Russell[1] and Smith[2] have described sedimentary rocks of Cretaceous age, from Whatcom County to the north, and it is therefore inferred that removal of the 2,000 feet or more of the cover of the Jurassic batholith was toward the north. The series, as described by Smith, under the name Pasayten, begins with a conglomerate in which granitic bowlders predominate, is 6,000 feet or more thick, and is dynamically disturbed. The Mesozoic closed with a period of severe orogenic disturbance, as evidenced by the structural relations of Tertiary rocks. This unconformity is very marked, because the earliest Tertiary sedimentaries lie at distinct angular unconformity on the pre-Tertiary rocks, a break which is well described by Smith and Calkins in the Snoqualmie area.[1] The pre-Tertiary

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[1] I. C. Russell, "Cascade Mountains in Washington," *20th Ann. Rept. U.S.G.S.*, Part II (1898), p. 114; G. M. Dawson, "Geological Record of the Rocky Mountains in Canada," *Bull. Geol. Soc. Am.*, XII (1901), 84.

[2] Smith and Calkins, "Cascade Mountains in Washington," *20th Ann. Rept. U.S.G.S.*, Part II (1898), p. 114.

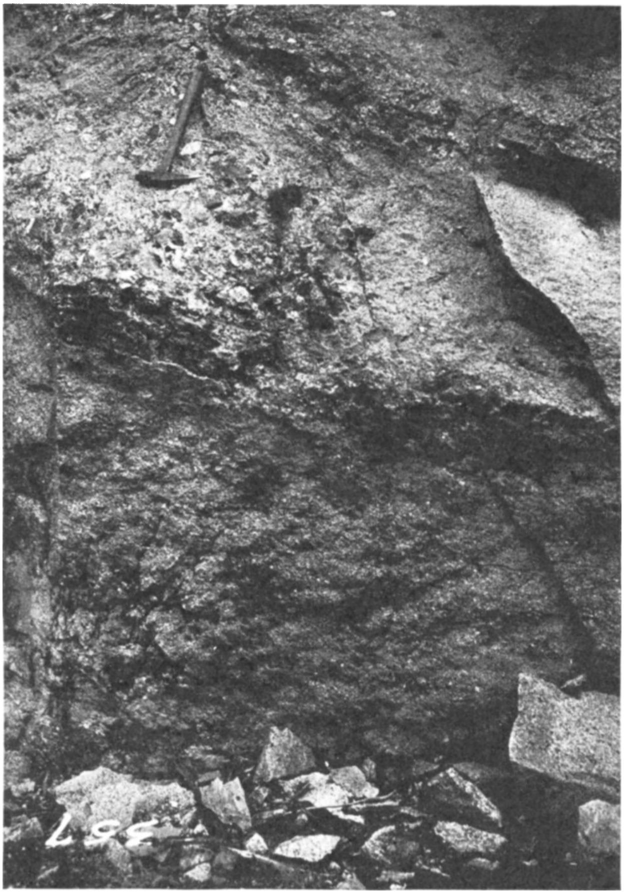

FIG. 1.—Swauk arkose series. Conglomeratic facies

disturbance left the area adjacent to the Skykomish Basin on the east in a condition sufficiently elevated to make the earliest Tertiary a period of erosion.

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[1] G. O. Smith and F. C. Calkins, *Folio U.S.G.S.*, 1906, 2.

III. TERTIARY

EOCENE

In the Skykomish area the Eocene was a period of sedimentation during which 4,000 feet of arkoses, shales, and conglomerates were deposited. About the middle of the series there are two shale formations which yield a considerable flora. The series is directly continuous with the Swauk series of the Snoqualmie quadrangle, and is also related to it on paleontologic grounds. It outcrops in a belt several miles in width, striking approximately N. 45° W. in the Eagle Creek-Beckler and the Foss River valleys. The dips vary; in the measured section, half a mile south of the Great Northern Railway, the base of the series lies nearly level, with increasing dip to the east as one goes east, and to the west as one goes west, until the top of the series stands vertical. It is an anticline whose basal beds rest unconformably on Easton schist, and whose roof is a part of the Keechelus andesite series.

Miss Duror's appended report is made on the flora collected from two horizons about 600 feet apart vertically, the lower being 1,100 feet from the base of the Swauk. Fossils numbered F 831, F 831+50, and F 844 are from the upper beds; those numbered F 865 from the lower. With the latter is associated a coal bed some 14 inches thick on which slopes have been driven in the hope of finding minable coal.

The sandstones and conglomerates are cross-bedded and the fragments usually angular and never assorted (Fig. 1). It has been considered a fresh-water lake deposit. In the light of the recent developments of stratigraphy it may better be classed as in part purely continental and in part deposited by streams, probably in deltas. The shales, and particularly those carrying complete specimens of *Sabal*, could only have been laid down *in situ* and must have been formed in shallow water—probably in a swamp. None of the series bears evidence of deposition in deep water, and both the angular condition and the considerable size of the fragments forbid their having been transported for any great distance.

Correlation.—Knowlton has done the paleontologic work on the continental Eocene of Washington. He has made the determinations both for the Eocene (Puget) of western Washington and for the Eocene (Swauk, Teanaway, and Roslyn) of eastern Washington. Continual reference is therefore made to him as an authority. The original report on the Swauk[1] showed 25 species belonging to the following genera: *Lygodium*, *Sabal*, *Myrica*, *Comptonia*, *Populus*, *Quercus*, *Ficus*, *Cinnamomum*, *Prunus*, *Diospyros*, *Zizyphus*, *Celastrinites*, *Phyllites*. Of these genera, *Sabal*, *Populus*, and *Ficus* are reported by Miss Duror from the Skykomish Basin, and both *Sabal* and *Ficus* are index fossils of the lower Eocene (Puget), as stated by Knowlton: "The following genera have been found in the lower beds but not at all in the upper: *Cladophlebis*, *Lastrea*, *Siphonites*, *Ficus*, *Eucalyptus*, and *Aralia*."[2] Turning to the western area we find that the Puget formation consists of some 10,000 feet of arkoses and intercalated carboniferous shales representing the Eocene. Besides the above named, Knowlton describes *Quercus*, *Juglans*, *Rhamus*, *Populus*, and *Laurus* from that series. Of these Miss Duror reports *Juglans*, *Populus*, and *Laurus*, and the presence of *Ficus* and *Sabal* correlates the Swauk with the lower Puget (Carbonado). Miss Duror's report further proves the equivalency in age of the Swauk with the Fort Union of Montana, North Dakota, and Wyoming.[3] The Swauk sedimentary series may then be correlated with the lower Puget of western Washington, with the Swauk (lowermost Eocene) of eastern Washinton, and with the Fort Union areas farther east.

MIOCENE

Keechelus.—This series of rocks of volcanic origin comprises tuffs, sheets, and dikes usually of andesitic but less frequently of dacitic composition. The tuffs predominate strongly and form beds of unknown but considerable thickness widely distributed in the Skykomish Basin. They overlie the Swauk sandstone, and the dikes have baked the sandstones. The Keechelus is therefore post-Swauk in age. Contrariwise, the Keechelus series has been indurated and otherwise metamorphosed by the Snoqualmie batholith to the southward; in the Snoqualmie area the Keechelus series is underlaid by a sedimentary series of sandstones and water-laid pyroclastics (Ellensburg) which contains flora called Upper Miocene by Knowlton.[1] The Keechelus series in the Skykomish Basin, being really continuous and lithologically identical with the series of the southern area, is therefore considered Miocene in age. As has been pointed out by Smith and Calkins, a striking chemical similarity exists between the Keechelus andesite and the subjacent body of granodiorite. Both fall into the same chemical classification—tonalose. It is immediately inferred that the two rocks are consanguineous, or, in other words, that the andesitic pyroclastics were blown out from a magma that later solidified as the Snoqualmie granodiorite. We must assume 2,000 feet or more of cover, and it is suggested that this Keechelus series may very well have provided at least a part of the cover which has later been removed by processes of erosion. No estimate can be made of the thickness of the Keechelus series. It is undoubtedly widely variable and probably had a thickness of several thousand feet.

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[1] *Folio 106, U.S.G.S.*, 1904, p. 5.

[2] *Folio 54, U.S.G.S.*, 1899, p. 3.

[3] A. G. Leonard, "Cretaceous and Tertiary Formations," *Jour. Geol.*, XIX (1911), 541–43.

Snoqualmie granodiorite.—Into the Keechelus series was intruded one of the younger of the known great batholithic intrusions. It has a known length of major axis of about thirty miles and is approximately two-thirds as broad. Throughout, this terrane is a massive, fresh, granitoid igneous rock which has been discovered by erosion to a vertical depth of 5,000 feet or more. It has, as was seen above, metamorphosed rocks of late Miocene age, and has sent apophyses into them, and therefore must itself be Miocene or later in age. To account for its holocrystalline nature and for the fact that it has been peneplaned, uplifted, and maturely dissected, it seems necessary to put the date of its intrusion as near that of the Keechelus as possible. The age is therefore given as late

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[1] G. O. Smith and W. C. Mendenhall, "Tertiary Granite in Northern Cascades," *Bull. Geol. Soc. Am.*, XI (1900), 224; G. O. Smith and F. C. Calkins, *Folio 139, U. S. G.S.*, 1906, p. 8.

Miocene, in accordance with Smith's interpretation.[1] The only metamorphic effects experienced by this rock are the slight clouding of feldspars and the formation of a system of joints. There is a southernmost corner of another batholith, or, more likely, of a subjacently connected continuation of the same batholith, north of Grotto, and it is probable that these Tertiary batholiths form the core of the Cascade Range throughout the northern half of the state. Daly has correlated several of his batholiths with the Snoqualmie batholith.

PLIOCENE

There is no stratigraphic evidence of Pliocene history. It is physiographic rather. We infer that the Snoqualmie batholith had a cover in excess of 2,000 feet in thickness. This cover was removed and the entire area reduced to one of low relief in late Miocene and post-Miocene time. In the Pliocene the area was uplifted with a broad arch of north-south trend and with certain minor warpings of transverse trend. Subsequent to this uplift, but still in the Pliocene, the area was maturely dissected by steam action. This process of peneplanation, uplift, and mature dissection is evidence of the very considerable duration of the Pliocene.

PLEISTOCENE

This is the age of glacial occupancy, when glaciers of the alpine type filled the valleys to a depth of several thousand feet and flowed down to their confluence with the Piedmont glacier of Puget Sound. Evidence has been put forward by many writers of two periods of glacial advance in the Puget Sound Basin, but of course the last alpine glacier to occupy the valley would have destroyed all evidence of any previous glaciation, and it can only be said that the Skykomish Basin was maturely dissected by glaciers of the alpine type in Pleistocene time. Comparatively little time has elapsed since the glaciers withdrew from the valley. The only stratigraphic evidence of this period is the accumulation to a depth of several inches of a volcanic ash which has only a slight soil covering at present—an evidence of recent volcanic activity in the near-by volcanic cones.

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[1] G. O. Smith and W. C. Mendenhall, "Tertiary Granite in the Northern Cascades," *Bull. Geol. Soc. Am.*, II (1900), 201–28.

RÉSUMÉ

Eocene time witnessed the accumulation of 4,000 feet of arkose sandstone. This was orogenically disturbed so that it now dips at considerable angles. In the Miocene a series of volcanic tuffs and andesitic intrusives were derived from a magma which approached the surface and cooled as a batholith in late Miocene. Pliocene saw the formation, uplift, and mature dissection of a peneplane. The Pleistocene was a period of glaciation lasting nearly to the present, in which the Skykomish area was maturely dissected by ice erosion.

IV. STRUCTURE

A glance at the map shows the tendency of all formations to trend north-south. Only the Swauk arkose series deviates from this tendency, and even this formation tends to assume a normal relation in its northward outcrop. The great igneous terrane (Miocene batholith) has its major axial trend in a direction parallel to the north-south axial trend of the Cascade Range.

JOINTING

There are two known systems of joints of considerable importance and one or more of less prominence. The first two strike N. 45° E. and N. 70° E., respectively, and the lesser system strikes N. 80° W. It is suggested that these joints are the result of pressure exerted by orogenic forces in raising the Cascade peneplane to its present position. If this pressure were exerted continuously in an east-west line from the Pacific side, we should anticipate a set of joints striking N. 45° E. and a lesser set striking N. 45° W.[1] At least one important set of joints does strike N. 45° W. in the Cleopatra Mine. But it is necessary to postulate a change in the direction of application of the force to account for the system of joints striking N. 70° E. and N. 80° W.[2] It seems possible that such a change may have taken place in the direction of application of orogenic pressure, and this change may account for the transverse warping of the surface of the peneplane which is noted elsewhere. The importance of the development of these structural relations has an important influence on ore deposition (Fig. 2).

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[1] A. Daubrée, *Géologie expérimentale* (1879), pp. 316 f.

[2] G. F. Becker, "Finite Strain in Rocks," *Bull. Geol. Soc. Am.*, IV (1893), 23.

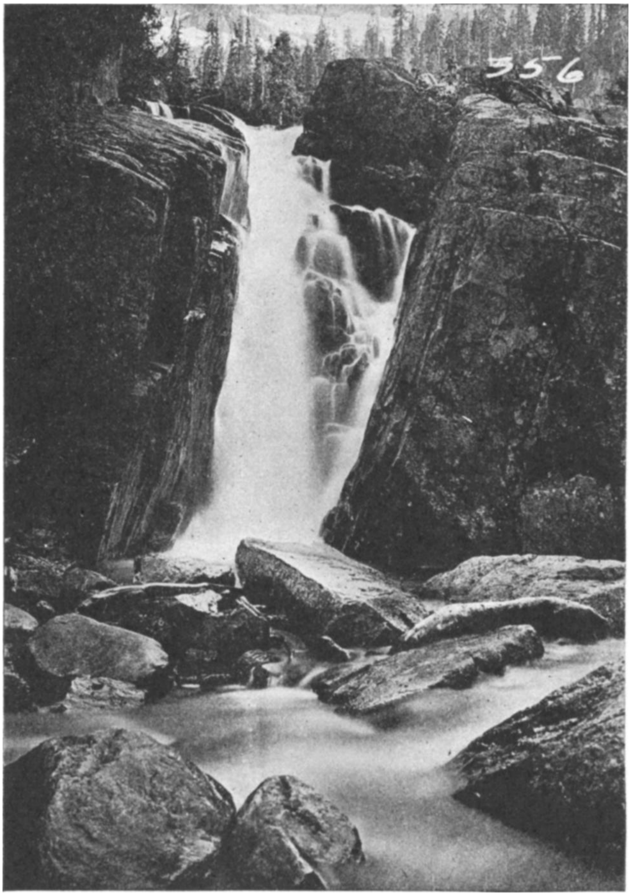

FIG. 2.—Kimball Creek. Note jointing. Rock: granodiorite

REPORT ON THE FLORA OF THE SWAUK SERIES

The flora of the beds is of Fort Union age. The material examined yields fifteen genera and nineteen species, of which two are new; the other seventeen species have been recorded from

Fort Union beds. Three ferns are represented by abundant specimens of *Asplenium* and *Pteris* in the shales of F 831 and F 831+50.

Genus *Asplenium*

Asplenium magnum var. *intermedium* var. *novum* (Duror) (Fig. 3)

Knowlton: "Fossil Flora of Yellowstone Park," extract, *Mono. XXXIII, U.S.G.S.*, 1899, Part 2, p. 667; Pl. LXXIX, Figs. 8, 8*a*.
Heer: *Flora Foss. Arct.*, Vol. IV, "Ostsibriens," Taf. XX (*A. whitbiense*).

This form is so named because it is intermediate in character between *A. magnum* (Knowlton) and *A. whitbiense* (Heer). The frond is not pinnate, but the lobes are cleft one-half to one-third of the distance to the rachis. The margin of the lobes is entire. These lobes are one and one-half to twice as long (along midvein) as broad and come to a rounded point. Secondary veins come off at an angle of about 45°, members of each pair being almost opposite. Each secondary bears eight to ten pairs of tertiaries, which are generally once forked. A few rare cases of simple secondaries and still fewer twice-forked secondaries were observed. The variety differs from *A. magnum* of Knowlton in possessing almost deltoid instead of ovate lobes and in being rather larger. This form is separated from *A. whitbiense* of Heer, because here most secondaries fork once only, and because Heer's form has true pinnules—the form being bipinnate. There is no suggestion that this form is fully even once pinnate.

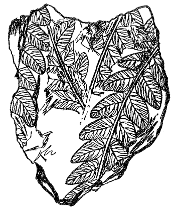

Fig. 3.—*Asplenium magnum* var. *intermedium* var. *novum*. (¼ natural size.)

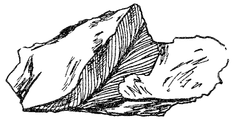

Fig. 4.—*Pteris pennaeformis*. (½ natural size.)

Genus *Pteris*

Pteris pennaeformis (Heer) (Fig. 4)

O. Heer: *Fl. Tert. Helvetiae* (1855), p. 38; Taf. XII, Fig. 1*a–d;* Miocene age.
Lesquereux: *Tert. Flora* (1878), p. 52; Pl. IV, Figs. 3, 4, *Pseudopennaeformis*, Lower Lignitic age.

The Cascade specimens are quite similar to that figured by Heer, except that here only that part of the pinnae with entire margins is seen. Secondary veins are seen to fork twice, as in Heer's Fig. 1*e*, though from his description he found such nervation rare.

Genus *Sabal*

Sabal powelli (Newb.)

Newberry: *Proc. U.S. Nat. Mus.*, V (March 21, 1883), 504.
Later Extinct Floras of North America, p. 30; Pl. LXIII, Fig. 6; Pl. LXIV, Figs. 1–19; Tertiary (Green River group) age of Wyoming.

Palms are represented in these beds, chiefly in F 831+50 and in F 865, by numerous perfectly preserved specimens of this type. In some cases both upper and lower surfaces of the petiole of one leaf were preserved. The forms agree in all respects with Newberry's type.

GYMNOSPERMAE

Gymnospermae are represented by countless fragments of *Glyptostrobus*, *Sequoia*, and *Taxodium*—this last in greatest abundance. The greatest number of these forms is found in the shales of F 831+50.

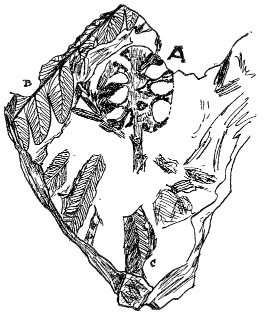

FIG. 5.—A, *Sequoia nordenskioldii;* cone in cross-section (natural size). B, *Asplenium cascadia.* C, *Taxodium distichum miocenum.* (½ natural size.)

Genus *Glyptostrobus*

Glyptostrobus ungeri (Heer)

Heer: *Flora Tert. Helvetiae*, I, 51; Taf. XIX, XX, Fig. 1; Taf. XLIX, Fig. 50. Newberry: (G. *Europaens* Brogn.): 1. *Annals N.Y. Nat. Hist.*, IX (1868), 43.
2. *Illus. Cret. and Tert. Plants* (1898), Pl. XI, Figs. 6–8*a*.
3. *Later Extinct Floras of N.Am.*, p. 24; Pl. XXVI, Figs. 6–8*a;* Pl. LXV, Figs. 3–4.

No cones of this species were found, but the general form of these fragments is like the Figs. 1*e* and 1*a* of Taf. XX, and of Fig. 50 of Taf. XLIX of Heer. They also resemble quite closely those from Birch Bay, Washington, figured by Newberry (see 3 above) on Plate LV. Those were of Fort Union age.

GENUS *Taxodium*

Taxodium distichum Miocenum (Heer), Fig. 5, C; Fig. 7, D.

Heer: *Miocene Baltische Flora* (1869), p. 18; Taf. II, III, Figs. 6, 7.
Newberry: *Later Extinct Floras of N.Am.*, p. 22; Pl. XLVII, Fig. 6; Pl. LI, Fig. 3, in part; Pl. LII, Figs. 2, 3, 4; Pl. LV, Fig. 5.
Lesquereux: *Tertiary Flora* (1878), VII, 223; VIII, 73.

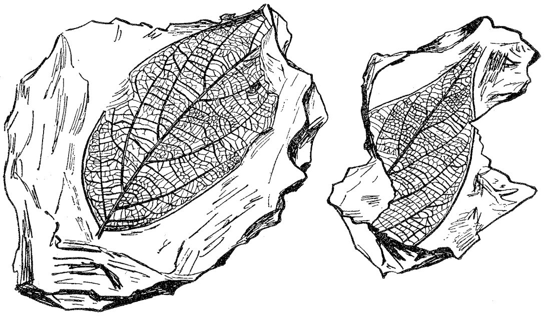

FIG. 6.—*Laurus cascadia* var. *leve*. (½ natural size)

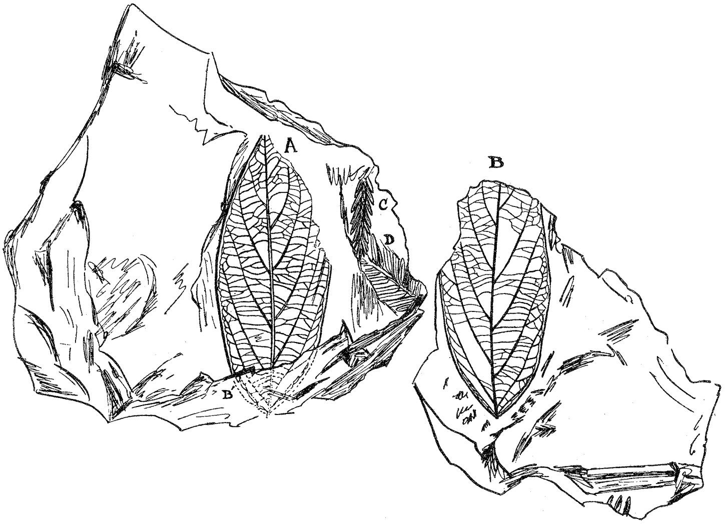

FIG. 7.—A, B, B^1, *Laurus cascadia*. C, *Sequoia nordenskioldii*. D, *Taxodium distichum miocenum*. (½ natural size.)

The Cascade specimens are quite typical. The form is Greenland Miocene or basal Eocene in age.

GENUS *Sequoia*

Sequoia nordenskioldi (Heer) (Figs. 5, A, 7, C, 8, B)

Heer: *Flora Foss. Arct.*, II ("Miocene Spitzbergens," 1870), 36; Taf. II, Fig. 13*b;* Taf. IV, Figs. 1*a*, *b*, 4–38.
Newberry: *Later Extinct Floras of N.Am.*, p. 20; Pl. XXVI, Fig. 4.

Sequoia nordenskioldi is represented by a few leafy branches occurring with the *Taxodium*, but in addition by a handsome cone. The cross-section is given in Fig. 5. The form is referred to *S. nordenskioldi* rather than to *S. langsdorfii* because the leaves are very little if at all narrowed before they join and run down the stem. The cone is almost identical with that of Heer (*op. cit.*, Taf. IV, Fig. 4*a*), except that these dimensions are 20×22 mm., not 16×13 mm., as Heer gives, and that here no leaves remain on the branch. This cone is not as elongate as in *S. langsdorfii.*

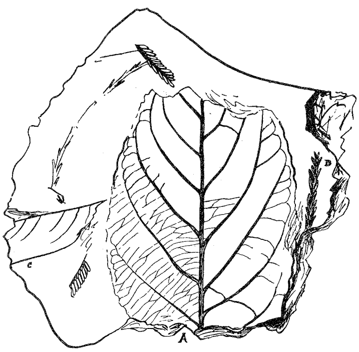

FIG. 8.—A, *Pterospermites whitei.* B, *Sequoia nordenskioldii.* C, *Sapindus obtusifolius.* ($\frac{1}{2}$ natural size.)

DICOTYLEDONS

There are no identifiable monocotyledons found in these beds. Dicotyledons are represented by ten fairly well-preserved forms, and by fragments of many more. The genera are: *Ficus*, *Juglans*, *Hicoria*, *Laurus*, *Magnolia*, *Populus*, *Protoficus*, *Pterospermites*, and *Sapindus.*

GENUS *Ficus*

Ficus ungeri (Lesq.)

Lesquereux: Supplement *Ann. Rept.*, 1871, p. 7; Fig. 1.
Hayden Survey, VII (1878), 195; Pl. XXX, Fig. 3.

Numerous fragments in F 831+ 50 beds are referred doubtfully to this form. The open-bowed secondaries in almost opposite pairs and the "very entire" margin are identical. Noted from Green River group, Middle to Upper Eocene.

Ficus sp. ? (Knowlton)

Knowlton: *Rept. on Fossil Plants Associated with Lavas of Cascade Range* (Western Oregon) (1898), p. 46; Pl. III, Fig. 1.

In shales (F 831+50) a specimen very similar to Knowlton's figure, in the roundly notched margin, and the 45° angle of emergence of the secondaries, was found. Here also no base or tip was to be seen.

GENUS *Hicoria*

Hicoria (Carya) *antiquorum* (Newb., Knowlton)

Newberry: *Ann. N.Y. Lyc. Nat. Hist.*, IX, (April, 1868), 72.
Illust. Cret. and Tert. Plants (1878), Pl. XXIII, Figs. 1–4.
Lesquereux: *Later Extinct Floras of N. Am.* (1868), p. 35, Pl. XXXI, Figs. 1–4.
Tertiary Floras (1878), VII, 289; Pl. I, Figs. 1–5; Vol. VIII, Pl. I, Fig. 2.
Knowlton: *Tertiary Plants of N.Am.* (1898), p. 117.
Fossil Flora of Yellowstone Park, etc.

This form is found in the sandy F 844 beds. It is referred to these species rather than to *Juglans nigella*, because the teeth are here rounded, as in *Hicoria*, and the secondaries are less prominent than in *J. nigella*. The leaf narrows gently toward the base and joins the stem (midvein) by a quarter-inch long winged "petiole." The form is noted by Newberry and by Knowlton from Eocene beds (*Planatus*) at the mouth of the Yellowstone River.

GENUS *Juglans*

Juglans acuminata (Heer)

Heer: *Flora Tert. Helvetiae*, p. 88; Taf. CXXIX, Figs. 2–8.
Flora Foss. Arct., VII, "Grönlands," 761; Taf. LXXV.
Knowlton: "Fossil Plants from Kukak Bay," *Alaskan Exp.*, IV (1904), 152; Pl. XXXIII, Fig. 3.

The form is identified from fragments only, but these are rather numerous. The entire margin and the angle of the midrib and secondaries are very similar in these specimens and in Heer's figures, but show considerable dissimilarity to Knowlton's type, where the angle between the midrib and secondaries is larger and where the latter are alternately long and short and bowed. The form, according to Heer, "is spread through the whole Tertiary and possesses many synonyms."

GENUS *Laurus*

Laurus cascadia N.Sp. (Figs. 6 and 7, A, B, B[1])

This specific name is given to several excellently preserved specimens in the shales of F 831. There is variation among the forms, but hardly more than to permit of naming of two varieties. The leaf is ovate lanceolate, coming to a sharp slender tip, and slightly unsymmetrical at the obtusely pointed base. There are six to eight pairs of strong secondaries, the members not directly opposite, besides a rather faint pair at the base, where the members are opposite. Secondaries come off at an angle of about 70° or less, as in Fig. 7, and are very gently bowed. The tertiaries show a horizontal parallel arrangement all the way across the leaf, so that they do not join the secondaries at right angles, except in the case of the two lower pairs. Fig. 6 shows preserved a fine network of veins between the tertiaries. The margin of the leaf is entire, and the ultimate veins border it in a series of loops. About one-quarter inch of petiole was found (Fig. 6). In Fig. 6 the breadth is 38 mm., the length probably 100 mm. The two pieces figured are not parts of one leaf. In Fig. 7 the dimensions are 32×80 mm., and here A and B are two sides of the impression of one leaf. A small form, very like Fig 6, but not drawn, was about 18×35 mm. *L. cascada* resembles *L. similis* of Knowlton (*Rept. on Fossil Plants Associated with Lavas of Cascadė Range of Oregon*, Pl. V, Figs. 1 and 4) merely in the horizontal tertiaries and in the angle of the secondaries. Tip and base are, however, quite different in the two forms. The base of *L. perdita* comes nearest to being as blunt as that of *L. cascadia.*

Laurus cascadia leve var. *nova* (Duror) and *L. cascadia* (type) differ largely, in that the former is proportionately broader and with somewhat heavier veins.

GENUS *Magnolia*

Magnolia nordenskioldi (Heer)

Heer: *Flora Foss. Arct.*, VII, "Grönlands," 123; Taf. CVIII, Figs. 2, 3; IV. "Spitzbergens," 82; Taf. LII, Fig. 1.

This reference is made doubtfully on certain fragments from the sandstone of F 844. The size of the leaf, strength, and irregular anastomosing of the secondaries of the veining are correct. The tertiaries, arising at right angles to the secondaries and dovetailing with the tertiaries from adjacent secondaries, are also similar to Heer's figures. The form is noted from the Canadian Miocene really Eocene.

GENUS *Populus*

Populus is represented by numerous more or less fragmentary remains, in which, however, many of the characters are fortunately plainly discernible. Three of Ward's species are believed to be present, besides one of Heer's. The three forms are noted from beds called Laramie, now considered of Fort Union age.

Populus amblyrhynca (Ward)

Ward: *U.S.G.S. Bull. No. 37* (1887), 20; Pl. VI, Figs. 1–8.

Reference of the forms to this species is made with great certainty. In the Cascade form the base is somewhat flatter than in Ward's figure, the identification resting chiefly upon the character of the thick tertiaries sent out from the inner side of the second pair of secondaries. The resemblance is closest to Ward's Figs. 2 and 3 of Pl. VI.

Populus cuneata (Newb.)

Newberry: *Later Ext. Floras*, pp. 31, 64.
Illus. Cret. and Tert. Plants, Pl. XIV, Figs, 1–4.
Lesquereux: *Cret. and Tert. Floras*, p. 225; Pl. XLVI, Fig. 5.
Dawson: "Cret. and Tert. Floras of Brit. Col. and N.W. Terr.," *Trans. Roy. Soc. Can.*, Sec. IV (1882), p. 32.
Ward: *U.S.G.S. Bull. No. 37* (1887), p. 19; Pl. IV, Figs. 5–8; Pl. V, Figs. 1–3.

One specimen was so called because the first pair of secondaries here, as in the figures of *P. cuneata*, leave the midrib about 5 mm. up from the attachment of the petiole.

Populus zaddachi (Heer)

Heer: *Flora Foss. Arct.*, I, 98; Taf. VI, Figs. 1–4; II, 468; Taf. XLIII, Fig. 15*a*; Taf. XLIV, Fig. 6.
Flora Foss. Alaska, p. 26; Taf. II, Fig. 5*a*.
Lesquereux: *Mem. Mus. Comp. Zoöl.*, VI (1878), No. 12; Pl. VIII, Figs. 1–8.

This form is referred to this species because it is remarkable for its larger size. Judging from a fragment, the complete leaf was about 4×6 inches, as is that of Lesquereux in Fig. 8. There are three pairs of secondaries, the lowest very faint, the innermost very strong and straight. The margin is not preserved. Lesquereux notes this form from Upper Miocene, but one of Heer's examples is Miocene of Spitzbergen (equal to Eocene).

Populus artica (Heer)

Heer: *Flora Foss. Arct.*, IV, Taf. XXXII.

The Cascade form is very questionably referred to this species. There is a single smooth, faintly veined leaf from beds F 831+50 whose base is almost cordate but otherwise agrees with *P. artica*, and even similar bases are to be found in Heer's figures.

GENUS *Protoficus* (*Saporta*)

Protoficus is represented by many beautifully preserved specimens from shales of F 831+50. They are apparently all of one new species.

Protificus fossi N.Sp. (Figs. 9 and 10)

The leaf is lanceolate, broadest just at the middle; the apex is a short, sharp point; the margin is irregularly, sharply dentate to one-third of the way to the base, then wavy to crenulate. The base is blunt to slightly tapering and not absolutely symmetrical, as seen in Fig. 10. The midrib is straight and moderately strong, with seven pairs of secondaries. The members of each pair are not strictly opposite, except above, where they are strongly bowed outward. The nervation has a palmate aspect, since the two lowest pairs of secondaries come off at the top of the petiole, and the rest only above the lower half of the leaf, or even higher. Six pairs of tertiaries arise from the second pair of secondaries and form loops near the margin. Small nerves extend from these loops into the teeth. All the other tertiaries are at right angles to the midrib in parallel "horizontal" rows. One small specimen measured 11 cm. in length by 4.5 in breadth (Fig. 10); the type (Fig. 9) is 9 cm. in width by 15 cm. in length.

The tertiary veination is similar to that of *Ficus tiliafolia* and there is also something of the same palmate look; but in *Ficus* the gap to the next pair of secondaries is only one-third as exaggerated as here. The margin of *F. tiliafolia*, moreover, is entire.

Protoficus zelleri of Lesquereux (*Bull. Mus. Comp. Zoöl.*, XVI, No. 12 [1888], 50), while described as notably palmate, is more cordate at the base and the border is merely crenulate. This leaf is only 7×5.5 cm.

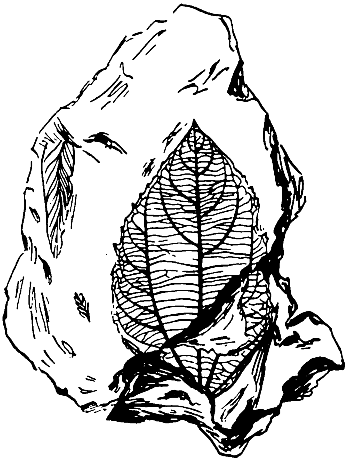

FIG. 9.—*Protoficus fossi.* (¼ natural size.)

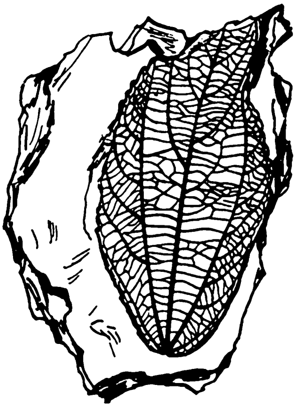

FIG. 10.—*Protoficus fossi.* (½ natural size.)

Protoficus inequalis (Newb.) (*Proc. U.S. Nat. Mus.* V [1882], 512) is not described as having a gap between the lower end and upper secondaries and is notably unsymmetrical at the base. The margin is merely undulate.

GENUS *Pterospermites*

Pterospermites whitei (Ward) (Fig. 8)

Ward: *U.S.G.S. Bull. No. 37* (1887), p. 94; Pl. XLI, Figs. 5 and 6.

The species from the shales of F 831+50 is in marked contrast to the foregoing *Protoficus*. The identification is rather certain, although the base and tip are wanting. The midrib is not quite so sinuous above as it is in Ward's figures. The form is noted from the Laramie of Montana, now conceded to be Fort Union in age.

GENUS *Sapindus*

Sapindus obtusifolius (Lesq.) (Fig. 8C)

Lesquereux: *Hayden Surv.*, VII (1873), 266; Pl. XLIX, Figs. 8–11; VIII, 235; Pl. XLVIII, Figs. 5–7.

Knowlton: *U.S.G.S. Bull. No. 204*, p. 79.

The form is represented by numerous fragments such as are shown in Fig. 8, C. Better specimens (not figured) show the typical, unequal base and the alternately stronger and weaker secondaries. Similar forms are described by Knowlton from the Fort Union of Montana and North Dakota.

The writer wishes to express her indebtedness to Dr. Arthur Hollick of the New York Botanical Gardens for valuable help and suggestions.

REPORT ON THE FAUNA OF THE MALONEY SERIES

Rafinesquina (Hall) *deltoidea* (Conrad) (Fig. 11, A, B, C, D), *Leptaena deltoidea* Conrad, *Am. Geol. Rept.*, 1838, p. 115.

Strophomena deltoidea Davidson, *Foss. Brachiopoda*, III (1864–71); Pl. XLII, Figs. 1–5; Pl. XXXIX, Fig. 22.

Streptorhyncus (*Strophonella*) *deltoidea* (Hall, 1883), *Sec. An. Rept. State Geol. of New York*, Pl. XLII, Figs. 1–7.

Rafinesquina deltoidea Hall, *Pal. New York*, VII; Part. I, p. 281; Pl. IX*a*, Figs. 1–5. (Same figures as in references above.)

The Cascade specimens are referred with slight hesitation to *Rafinesquina deltoidea*, notwithstanding the fragmentary nature of the material. There is a strong resemblance to *Plectambonites* (*Leptaena*) *sericius* (Sow.) var. *rhombica*, as figured in Davidson's *Fossil Brachiopoda*, V, 169; Pl. XII, Figs. 4–7. However, the remains of the muscle scars, and more especially the concentric wrinkles, stronger near the hinge line, are characteristic of *Rafinesquina*. The alternate striation, such as the Cascade specimens show, is described in both forms, "every fifth or seventh striation markedly stronger." Here generally every fifth striation, though rarely every seventh, and occasionally every second, is emphasized. Such a variation, and another in the profile of the shell, is noted by Professor M'Corq (quoted in Hall, *op. cit.*). In these specimens the most convex shell (Fig. 11, A, B) is not sharply flexed at any one point, while younger individuals, as in Fig. 11, C, show less arching, but a more sudden geniculation. The specimens are partly exfoliated and have a finely punctate surface.

Fig. 11, A, B, and D are of pedicle valves, and Fig. 11, C of a brachial valve. This last specimen is partly an impression of the outer surface of the shell, since the striations show as grooves; but part of the true shell remains where the muscle scars are shown.

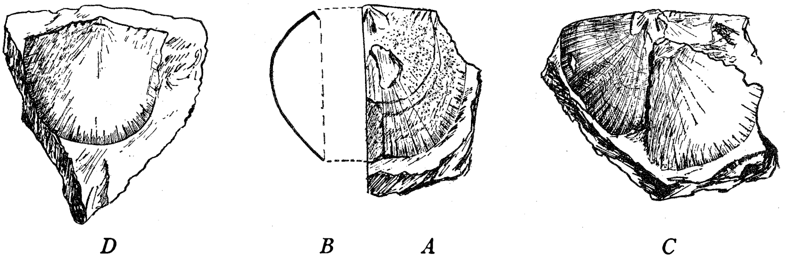

FIG. 11.—*Rafinesquina* (Hall) *deltoidea* (Conrad). A, B, and D, pedicle valves; C, brachial valve.

Illaenus americanus (Billings)

Billings (1859, quoted; 1865, quoted and figure copied): *Paleozoic Fossils*, I, 329; Fig. 316*a–d*.

Winchell and Ulrich: *Minn. State. Surv.*, III (1897), Part II, 714; Figs. (from above) 20, 21, 22, 23.

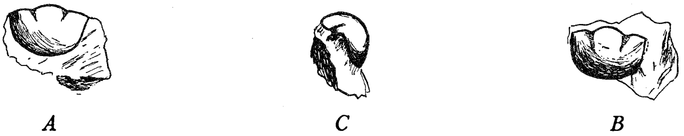

FIG. 12.—*Illaenus americanus* (Billings). A, front view; B, top view; C, side view.

A single specimen, the glabella and fixed cheeks, was found associated with the *Rafinesquina deltoidea*. All the features on these parts agree perfectly with Billings' figures. This specimen probably belonged to an animal one inch long, while Billings' forms ranged from two to three inches in length. Naturally, smaller forms have been noted, as in Grabau and Shimer, *Index Fossils*, p. 295, where one and one-fourth inches is given as the entire length.

Fig. 12, A is the front, Fig. 12, B the top, and Fig. 12, C the side view of the one specimen. The dotted line in Fig. 12, B gives the outline of the eye, which was destroyed in uncovering the fossil.

Both of these forms are index fossils of Trenton age. Naturally, they are not restricted to one bed, but in no case have they been recorded as younger than Ordovician.

The writer is indebted to Dr. Shimer and to Dr. Grabau for valuable help and advice.